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*Published in:*  
Procedia CIRP

*Link to article, DOI:*  
[10.1016/j.procir.2017.11.129](https://doi.org/10.1016/j.procir.2017.11.129)

*Publication date:*  
2018

*Document Version*  
Publisher's PDF, also known as Version of record

[Link back to DTU Orbit](#)

*Citation (APA):*  
Blomsma, F., Kjær, L. L., Pigosso, D. C. A., McAloone, T. C., & Lloyd, S. (2018). Exploring Circular Strategy Combinations - towards Understanding the Role of PSS. *Procedia CIRP*, 69, 752-757.  
<https://doi.org/10.1016/j.procir.2017.11.129>

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25th CIRP Life Cycle Engineering (LCE) Conference, 30 April – 2 May 2018, Copenhagen, Denmark

## Exploring circular strategy combinations - towards understanding the role of PSS

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### Abstract

This paper explores the concept of circular strategy combinations - situations where two or more circular economy strategies (reduce, reuse, recycle, reconditioning, etc) are present in a product system. Specifically, we focus on the holistic analysis of such configurations and the role of product/service-systems (PSS) in enabling them. The case of Riversimple, a sustainable mobility-as-a-service company, is investigated by means of the Circularity Compass in order to explore 1) how combinations of circular strategies can be identified and analysed, and 2) the role of PSS as an enabler of such combinations. This paper strengthens the body of work that aims to clarify how the PSS concept can be used to further develop the growing field of circular economy research and illustrate how the PSS concept can support the development of circular economy into a coherent concept.

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Peer-review under responsibility of the scientific committee of the 25th CIRP Life Cycle Engineering (LCE) Conference

**Keywords:** circular economy, life-cycle management, product/service-systems, resource productivity

### 1. Introduction

Circular economy (CE) can be regarded as an umbrella concept around the goals of improved resource productivity and value creation, and reduced value loss and destruction [1]. That is: CE groups a collection of waste and resource management approaches under its banner that have in common their potential to contribute to these goals. Strategies such as reduce, reuse and recycle (generally known as the ‘R’s’ or ‘Re- strategies’), we refer to as *circular strategies*. Within circular strategies we distinguish between four categories that each have different but sometimes overlapping enabling tactics: *preventative strategies* (i.e. efficiency, light-weighting, non-toxicity), *loop-closing*

*strategies* (i.e. recycling, composting), *loop-extending strategies* (i.e. cascading of materials and energy, downcycling, waste-to-energy), *longevity strategies* (i.e. maintenance, product durability, reconditioning (remanufacturing, refurbishment, upgrading)) and *intensification strategies* (i.e. product cascading, alternate use, sharing, co-use). We furthermore acknowledge enabling frameworks such as industrial symbiosis and product/service-systems (PSS).

Frequently, circular strategies feature as part of a *circular configuration*: as part of a product system where two or more circular strategies are combined and implemented alongside each other [2]. *Product system*, as used here, includes a product's entire life cycle and related activities: from the manufacturing process to distribution and the management/information components [3] and includes such operations as take-back, recycling and final disposal [4]. An example of a circular configuration in which three strategies are present is a product system that enables intensified use of products through redistribution (1), in which product longevity is extended by means of repair (2) and material recycling constitutes the final end-of-life strategy (3).

Circular configurations are at the heart of CE [1]: after all, instead of promoting one specific strategy, the CE concept invites us to consider a wide range of circular strategies. This furthermore implies that it is the creation of synergies and the management of trade-offs between strategies that take central stage within circular economy thinking. However, circular configurations are currently poorly understood: such questions as what circular configurations are likely to be effective and what conditions contribute to this (ownership structures, number of actors, relationship and responsibility of actors, benefit sharing, scale, etc), have so far not been systematically explored. Likewise, how combinations of circular strategies can be identified and analysed has not yet been theorised.

This leads to a myriad of ways of conceptualising and understanding the relationship between circular strategies, as Fig. 1 illustrates. This figure contains three examples of product systems in which a different number of circular strategies are identified, and where the relationship between them is conceptualised differently. Although these diagrams are not meant to facilitate the comparison of product systems, they reflect that case descriptions can suffer from the same lack of theoretical clarity that currently affects the CE concept as a whole [1]: apart from using the notion of looping or cycling, they have no common underlying structure and do not use a common vocabulary. Without a systematic way of describing where and how circular strategies affect product systems, the extraction of learnings on the level of circular configurations will be difficult to achieve.

To progress towards a better understanding of circular configurations, this paper explores how combinations of circular strategies can be identified and analysed. We undertake this exploration from the perspective of PSS - here understood as a solution that involves both a product and service aspects to satisfy customer needs [5], since PSS is highlighted as an important enabler for improved resource productivity and value creation, as well as for reduced value destruction [06, 07]. Moreover, a number of examples highlight the relationship of PSS with circular configurations: the exploration of PSS in the mobile phone sector by Suckling and Lee (2015) [08] highlights the potential of PSS for reuse, remanufacture and recycling; the case study of water purifiers for home use by Chun and Lee (2017) [9] looked at product maintenance and energy-in-use; and Allais and Gobert (2016) [10] examine reuse, remanufacturing and recycling as part of PSS scenarios for small household equipment.

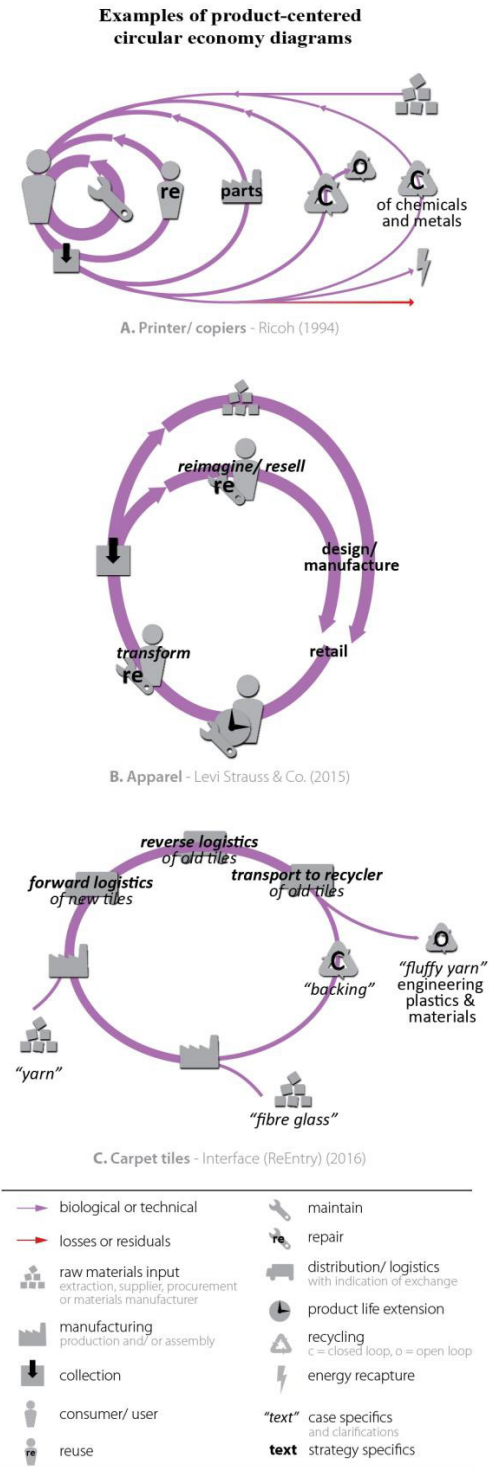


Fig. 1 These three examples of product centred circular diagrams are redrawn using the same visual language. They illustrate how different circular systems can be conceptualised: not only do they include different numbers and types of strategies, they also conceptualise the relationship between strategies differently. Variation on Fig. 1 in [01]: used with permission.

Apart from describing the possible role for PSS in enabling circular configurations, however, it has also been noted that PSS can have negative effects through rebound or total adverse effects as a result of, for example, users exercising less care in utilising products [11, 12]. This leaves the role of the PSS concept within the circular economy concept and its potential to positively contribute to establishing and maintaining circular configurations, unclear. For this reason, recent work has started to develop the theoretical basis that clarifies the relationship of the PSS concept with the CE concept, such as Kjaer et al (forthcoming 2018) [13] who have compiled a comprehensive set of conditions under which PSS can be justifiably called ‘circular.’ A second example is Corvellec and Stal (2017) [14] who use a waste-centric analysis of PSS, based on the Waste Hierarchy [15] and Tukker’s PSS classification [16], to create critical insights into the potential of PSS to contribute to dematerialisation, decoupling, and sustainability.

This paper aims to strengthen this body of work by clarifying how the PSS concept can be used to develop the relatively new field of circular economy research [17] and support the development of circular economy into a coherent concept [1], through use of the circular configurations concept. To this purpose, one case example is used to explore 1) how circular configurations can be identified and analysed, and 2) the role of PSS as an enabler of such configurations.

This paper is structured as follows. First, the methodology used in this paper is explained, clarifying the reasons for the selection of the case and the analytical method. Next, the Riversimple case is introduced and analysed in more detail. The results section discusses the relationship between the circular strategies and the PSS combination present in the case. The conclusion section presents the implications of adopting this holistic analysis method for circular economy research and summarises opportunities for further work.

## 2. Methodology

This paper is exploratory in nature. For this reason, an illustrative case was selected to describe the phenomenon of circular configurations in relation to PSS and it was investigated using the Circularity Compass [2]. The Circularity Compass is a visual mapping method that allows for capturing resource flows and circular strategies from the perspective of an industrial system, in a systematic manner.

The Circularity Compass uses thermodynamic principles to distinguish between ‘high’ and ‘low’ entropic resource states - or disorder and order as seen from a product perspective. Put simply, this is a way of indicating where a resource is on its journey to constituting a finished good, see also the state indicator in Fig. 2 (left). Specifically, the Circularity Compass identifies three states: *particles*, *parts* and *products*. The particles state is where one would speak of resources in terms of materials, molecules and substances. Next, particles are given an intermediary form in the parts state. This is where parts or components and (sub)assemblies are created or where they are accessed through (partial) disassembly for maintenance, repair and remanufacturing. Lastly, parts are assembled to form finished goods that end users can extract value and utility from in the products state.

In the analysis of the case a simplified version of the Circularity Compass was employed which excludes losses and waste generated during manufacturing and pre-consumer cycling. Various sources were used to compile the case description, among which information from the company website as well as academic publications and company presentations. The compounded information was verified by the company. The sources were analysed for the presence of circular strategies and mapped onto the Circularity Compass. Next, the relationship of the identified strategies with the present PSS was analysed.

## 3. Introducing Riversimple: sustainable MaaS

Riversimple is a company in Wales (UK) that aims to offer mobility-as-a-service (MaaS): selling miles instead of car ownership, with a particular focus on sustainability. Currently, the company is exploring multiple business models: the first offers personal mobility, the second is based on shared car use. Both offerings include a fixed monthly fee and a variable fee based on miles driven. Riversimple’s offering includes use of the car, fuel, insurance and maintenance [21].

Riversimple’s starting assumption is that conventional cars are not as efficient as they could be and are over-specified for conventional use [18,19]. For a start, car manufacturers do not have as their starting goal to provide the most efficient cars possible: their profits are not directly correlated to the fuel efficiency of their cars. Moreover, typically only 14-30% of fuel energy drives vehicles: the rest is lost as a result of power-transmission inefficiencies and powering ancillary items [20]. In addition, of the 4-5 seats, only 1 or 2 are frequently used. Finally, the top-speed possible is often lower than the actual top-speed driven, resulting in larger engines than necessary. In terms of usage patterns, cars are not optimised for frequent starting, stopping and accelerating characterised by city road use. By taking a whole systems approach, meaning that the car is designed specifically with radical efficiency in mind for a maximum of two occupants, with lower top-speeds, with acceleration decoupled from cruising demands, by removing accessories and providing ‘luxury minimalism’, Riversimple’s hydrogen-powered Rasa prototype is between 2.3-3.7 times lighter than other environmentally conscious car designs (see [19]).

Riversimple’s PSS is a use-oriented PSS [16]: the product ownership remains with the PSS provider, but the customer has access to the product. It is anticipated that after every third year the cars will be ‘refreshed’ both ‘cosmetically and practically’, before being returned to operation ([19]:3). The cars can be made using distributed manufacturing: that is, the design is suitable for producing relatively small series, with factories placed close to where the cars will be deployed. This, it is argued, reduces the risk of over-production [19].

As well as offering a performance-based service to its customers, Riversimple encourages its suppliers to do the same. The company refers to this as ‘upstreaming the sale of services’. Practically, this would mean that the company would lease parts or sub-assemblies from its suppliers through a use-oriented PSS offering [16], which can include repair, refurbishment or remanufacturing. The idea behind this is that

such an approach would align interests along the supply chain and make longevity and durability a quality of every aspect of the product. Although no such contracts are in place at the moment, the company is actively pursuing this approach.

#### 4. Analysis of Riversimple case using Circularity Compass

In this section, the role of circular strategies in the Riversimple case is further analysed, using the Circularity Compass. Fig. 2 illustrates the circular strategies as the company aims to put in place. As an example, two parts are included here that are supplied under a lease agreement (the two thinner arrow). As this example is hypothetical, the flow magnitude is merely indicative.

Firstly, if Riversimple's model is successful in replacing individual car ownership, it prevents product over-capacity by designing specifically for a maximum of 2 users. This means that fewer resources need to be used, compared to a conventional car. As such, this strategy can be classified as a preventative strategy in the particles state (P01). This has knock-on effects for energy in-use, which can be dramatically reduced by the lower weight and the whole-systems design approach to more efficient power transmission. Therefore, one can also speak of a preventative strategy in the products state

fuel consumption. This can be identified as another preventative strategy in the products state (P03).

Secondly, by offering a performance-based model, it is the expectation that car ownership can be reduced by “removing the fashion element of new models, reducing associations of prestige and status [and instead] focusing on the core of providing personal mobility. In so doing, the demand for continuous upgrade and replacement is addressed, potentially radically reducing production demand and car usage” [18]. This stimulates product longevity, thus introducing a longevity strategy to the products state (L01). Importantly, when part of a shared car use scheme, this system has the capacity for increased utilisation based on intensified use, as the cars can be used by multiple individuals. This strategy can be identified as a products state intensification strategy (I01).

Thirdly, longevity of the product is enhanced through the choice of material for the body, which can be designated as a longevity strategy in the particles state (L02). This is due to the composite material offering greater longevity compared to the conventional steel, the deterioration beyond economic support of which is the most common cause for vehicles reaching their end-of-life ([20], in: [19]). However, this longevity strategy comes at a price: the composite material is currently not commercially recyclable and also requires higher energy

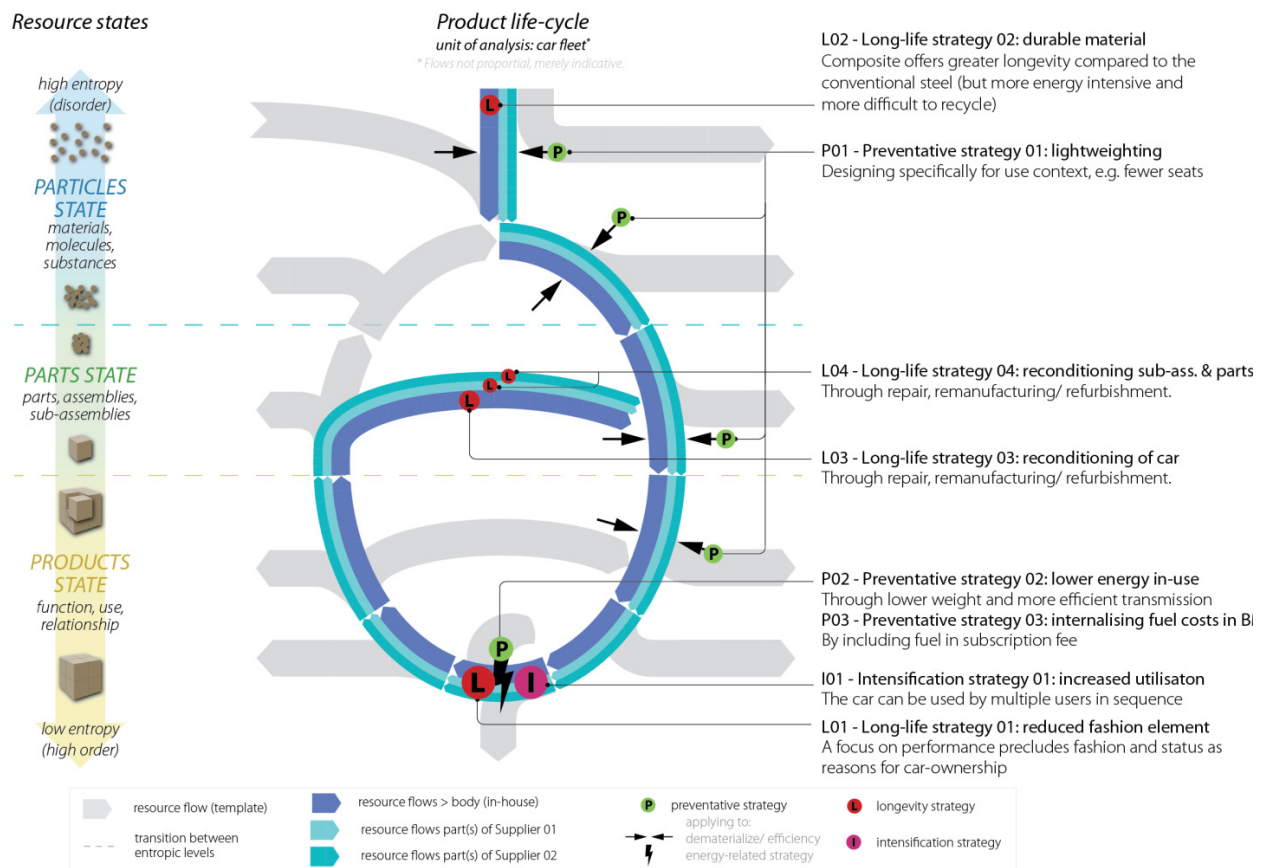


Fig. 2 Circularity Compass with Riversimple case mapped onto it.

(P02). Importantly, an added incentive for reducing energy-in-use is the inclusion of fuel in the subscription fee the user pays to Riversimple, making it in the company's interest to reduce

during manufacturing [19]. As such, a trade-off was made between longevity and loop-closing.



Lastly, Riversimple's model includes various forms of reconditioning. Firstly, the car as a whole will be reconditioned every three years, meaning that it will be thoroughly cleaned, that preventative maintenance will be applied and that worn-out parts and sub-assemblies will be replaced. This benefits the longevity of the product as a whole. As this requires (partial) disassembly, it is identified as a longevity strategy in the parts state (L03). In addition to this, some of the parts and subassemblies could be remanufactured as part of the lease agreement with the suppliers. This means that the lifespan of these individual parts and sub-assemblies is also extended beyond a single use-cycle (L04). This adds a longevity strategy to both of these parts and these strategies are therefore labelled as longevity strategies in the parts state.

In total, eight distinct strategies could be identified; three preventative; three product-longevity strategies; one product intensification strategy; and one longevity strategy, which affects two parts/subassemblies. Discussed next is how these strategies differ, with regards to the flows they affect and also with regards to the stages of the product life cycle they affect.

## 5. PSS as circular strategy & configuration enabler

Having identified the circular strategies present in this case, it is now possible to examine circular configurations in relation to PSS. First of all, note that the application of circular strategies is a direct result of an orientation towards performance. That is: the company aims to provide the most efficient service possible, with minimum investment requirements and the lowest possible operating-costs. Arguably, a similar system can also be envisaged, without the inclusion of fuel in the subscription. However, this would mean that the benefits of the reduced fuel use accomplished by the whole systems design approach would primarily benefit the user, not the company. In such scenarios, reduced fuel use would not contribute to the company's bottom line. Thus, by aligning the company's interests with that of the environment, when it comes to fuel use the company turns the inclusion of fuel in the subscription into an opportunity for improved competitiveness. In turn, this enables various circular strategies.

Secondly, the analysis using the Circularity Compass brought to the fore that the different PSS target different resource states. The two examples of supplier PSS as included here primarily affect the parts state, where the PSS offered by Riversimple to its customers seems to affect all three resource states. As such, use of the Circularity Compass allows for clarification of what flow is 'circularised' where in the product system.

Thirdly, the analysis brought to the fore the related nature of the various circular strategies and how synergies can be created between them, such as between preventative strategies P01 and P02. Trade-offs could also be detected, such as between the longevity and recyclability of the car body. Moreover, a gap in the configuration could be noted: Fig. 2 does not contain end-of-life strategies aimed at materials (consulted sources did not elaborate). This may indicate that further work is required in this area. As such, the Circularity Compass supports the identification of relationships between circular strategies, as

well as the identification of areas where strategies can potentially be added.

The company's ambition to align interests across stakeholders in the product system extends to their supply chain, as was illustrated by the company's ambition to have access to the components of their cars through performance-based contracts. Two examples were included to explore what such a configuration could look like. The first notable aspect about the presence of these two PSS examples is that they affect different parts of the product's life cycle, compared to the service that Riversimple is offering its customers. That is: where the PSS that Riversimple offers its customers also involves circular strategies in the products state, the two examples primarily target the parts state. In other words, the service that Riversimple will offer its customers also targets the product use phase, where the two suppliers of services to Riversimple primarily support reconditioning. In this product system, Riversimple takes on the role of *service aggregator/integrator*, in order support resource productivity across different life cycle phases.

In effect, describing circular strategies using a mapping method like the Circularity Compass – and therefore taking into account the resource states and life cycle phases – and attributing the different strategies to the PSS combination present, allows for the description of the relationships between circular strategies in a holistic and consistent manner. Similar analyses on more cases allows for the identification of patterns that may provide insight into particularly effective configuration types and the conditions that enable them. With this, the focus is not on individual circular strategies or on the PSS business model (e.g. renting, leasing, sharing) that is employed, but on how strategies can be brought together in a synergistic manner by enabling frameworks such as PSS.

## 6. Discussion and conclusion

Through analysing an illustrative case – mobility-as-a-service company, Riversimple – by means of the Circularity Compass, this paper explored: 1) how circular configurations can be identified and analysed; and 2) how PSS enables such configurations. Discussed next are the implications of these insights for circular economy research.

The analysis presented in Fig. 2 made apparent the synergistic nature of circular strategies and the role of PSS combinations in enabling this. This paper, and the work it builds on, merely represents attempts at exploring the area of circular configurations and the need to integrate knowledge from various disciplines to provide CE with a theoretical grounding. As such, further work is required to develop the Circularity Compass or similar methods into a generically applied method. For this to become possible, a consensus needs to be built around waste definitions (see [02] for the range currently in use) and definitions of circular strategies. This would allow for the creation of larger datasets of cases that can be mined for (un)successful configurations, which can then be studied further to deepen our understanding with regards to enabling conditions, which can then guide resource management and policy. The method could also be developed further to support quantification of resource productivity and

sustainability impacts by linking it with known quantification methods and sustainability assessment approaches.

The fact that in the Riversimple case a focus on performance is essential in order to generate the circular configuration, points to the potential of the PSS concept to serve as a grounding for the further development of CE. That is: the PSS concept may be used as a foundation to further build and elaborate on, when combined with a perspective that includes resource productivity and waste. This is not a new insight (e.g. Stahel 2006, Corvellec and Stal 2017). However, we would like to add that this implies a broadening and possible adaptation of PSS language, methods and tools to be able to describe and account (better) for circular economy aspects. Examples of this are the type of analysis as was presented for the Riversimple case, which combines conventional PSS typologies with circular strategies, circular configurations and life cycle stages, and the creation of a case database for pattern-finding and generating a deeper understanding of the role of PSS. Another such addition is the role of organisations as service aggregator/integrator. This is a phenomenon that seems increasingly important, with other examples of companies putting this in practice such as CPH Village [24] This role implies that PSS combinations can best be understood in relation to each other, which points to a need to further elaborate and build on the notion of PSS ecosystems (e.g. [25], [26]).

In summary, the following opportunities for future theoretical work can be identified that would support the development of circular economy into a coherent concept: 1) developing a standard classification of circular strategies; and 2) a broadening and possible adaptation of PSS language, methods and tools to be able to describe and account (better) for circular economy aspects such as circular configurations.

## References

- [1] Blomsma, F. & Brennan, G., 2017. The emergence of circular economy - a new framing around prolonging resource productivity. *J. Ind. Ecol.*
- [2] Blomsma, F., 2016. Making sense of circular economy - how practitioners interpret and use the idea of resource life-extension. Imperial College London.
- [3] EPA (U.S. Environmental Protection Agency), 1993. Life Cycle Design Guidance Manual: Environmental Requirements and the Product System.
- [4] ISO (International Organization for Standardization), 2012. Environmental Management e Eco-efficiency Assessment of Product Systems e Principles, Requirements and Guidelines. ISO 14045:2012, Geneva, Switzerland.
- [5] Haase, R.P., Pigosso, D.C.A. & McAloone, T.C., 2017. Product/Service-System Origins and Trajectories: A Systematic Literature Review of PSS Definitions and their Characteristics. *Procedia CIRP*, 64, pp.157–162.
- [6] Stahel, W., 2006. *The Performance Economy* 2nd ed., Palgrave MacMillan.
- [7] EMF (Ellen MacArthur Foundation), 2013. *Towards a Circular Economy - Economic and Business Rationale for an Accelerated Transition*, EMF publications.
- [8] Suckling, J. & Lee, J., 2015. Redefining scope: the true environmental impact of smartphones? *Int. J. of Life Cycle Assessm.*, 20(8), pp.1181-96.
- [9] Chun, Y.-Y. & Lee, K.-M., 2017. Environmental impacts of the rental business model compared to the conventional business model: a Korean case of water purifier for home use. *Int. J. of Life Cycle Assessment*, 22(7), pp.1096–1108.
- [10] Allais, R. & Gobert, J., 2016. A multidisciplinary method for sustainability assessment of PSS: Challenges and developments. *CIRP Journal of Manufacturing Science and Technology*, 15, pp.56–64.
- [11] Manzini, E., Vezzoli, C., 2002. *Product-service Systems and Sustainability: Opportunities for Sustainable Solutions*. United Nations Environment Programme, (UNEP), Nairobi.
- [12] Tukker, A., 2015. Product services for a resource-efficient and circular economy - A review. *Journal of Cleaner Production*, 97, pp.76–91.
- [13] Kjaer, L.L., Pigosso, D.C.A., Niero, M., Bech, N.M., McAloone, T.C., 2018 (submitted). Product/Service-Systems for a Circular Economy: the route to decoupling economic growth from resource consumption? *J. Ind. Ecol.*
- [14] Corvellec, H. & Stål, H.I., 2017. Evidencing the waste effect of Product-Service Systems (PSSs). *Journal of Cleaner Production*, 145, pp.14–24.
- [15] EC (European Parliament and Council), 2008. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain directives (Waste framework).
- [16] Tukker, A., 2004. Eight types of product-service system: eight ways to sustainability? Experiences from SusProNet. *Business Strategy and the Environment*, 13(4), pp.246–260.
- [17] Korhonen, J., Honkasalo, A. & Seppälä, J., 2018. Circular Economy: The Concept and its Limitations. *Ecological Economics*, 143, pp.37–46.
- [18] Bocken, N.M.P. & Short, S.W., 2016. Towards a sufficiency-driven business model: Experiences and opportunities. *Environmental Innovation and Societal Transitions*, 18, pp.41–61.
- [19] Wells, P., 2016. Degrowth and techno-business model innovation: The case of Riversimple. *Journal of Cleaner Production*, pp.1–7.
- [20] DOE, 2012. Where the Energy Goes: Gasoline Vehicles. United States Department of Energy. <http://www.fueleconomy.gov/feg/atv.shtml>. Accessed 30th May 2015. (in: [19])
- [21] Riversimple, 2017. How the business works. Available at: <https://www.riversimple.com/how-the-business-works> [Accessed October 2, 2017].
- [22] Tan, A.R., 2010. Service-oriented product development strategies. PhD Thesis. Technical University of Denmark (DTU).
- [23] Riversimple, 2017. Our partners and collaborators. Available at: <https://www.riversimple.com/our-partners-and-collaborators/> [Accessed October 2, 2017].
- [24] CPH Village, 2017. Available at: <https://www.cphvillage.com> [Accessed Nov. 13, 2017]
- [25] Mougard, K., Howard, T. J., McAloone, T. C., Neugebauer, L. M., and Bey, N. (2012). Establishing collaborative networks for conceptualising PSS Int. Design Conf., DESIGN2012, 21-24 May, Croatia, Dubrovnik.
- [26] Apitz, N., McAloone, T.C., Garcia i Mateu, A., Andersen, J.A.B., Mougard, K., Neugebauer, L.M., Hsuan, J. . (2013). PSS Organisation: A workbook in the PROTEUS series, PRO-5. Denmark: Technical University of Denmark.